

# STEREO – Heliospheric Imagers

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- HI status and operation *nominal*
  - Instrument paper – Eyles et al., 2009, Solar Phys. 254, 387
  - First light and review of first 2 years – Harrison et al., 2008, Solar Phys. 247, 171 & Harrison et al., 2009, Solar Phys. 256, 219
  - Calibration and performance – Brown et al., 2009, Solar Phys. 254, 185; Bewsher et al., 2010, submitted to Solar Phys.

00:09 UT, 15 February 2008



## STEREO – Heliospheric Imagers

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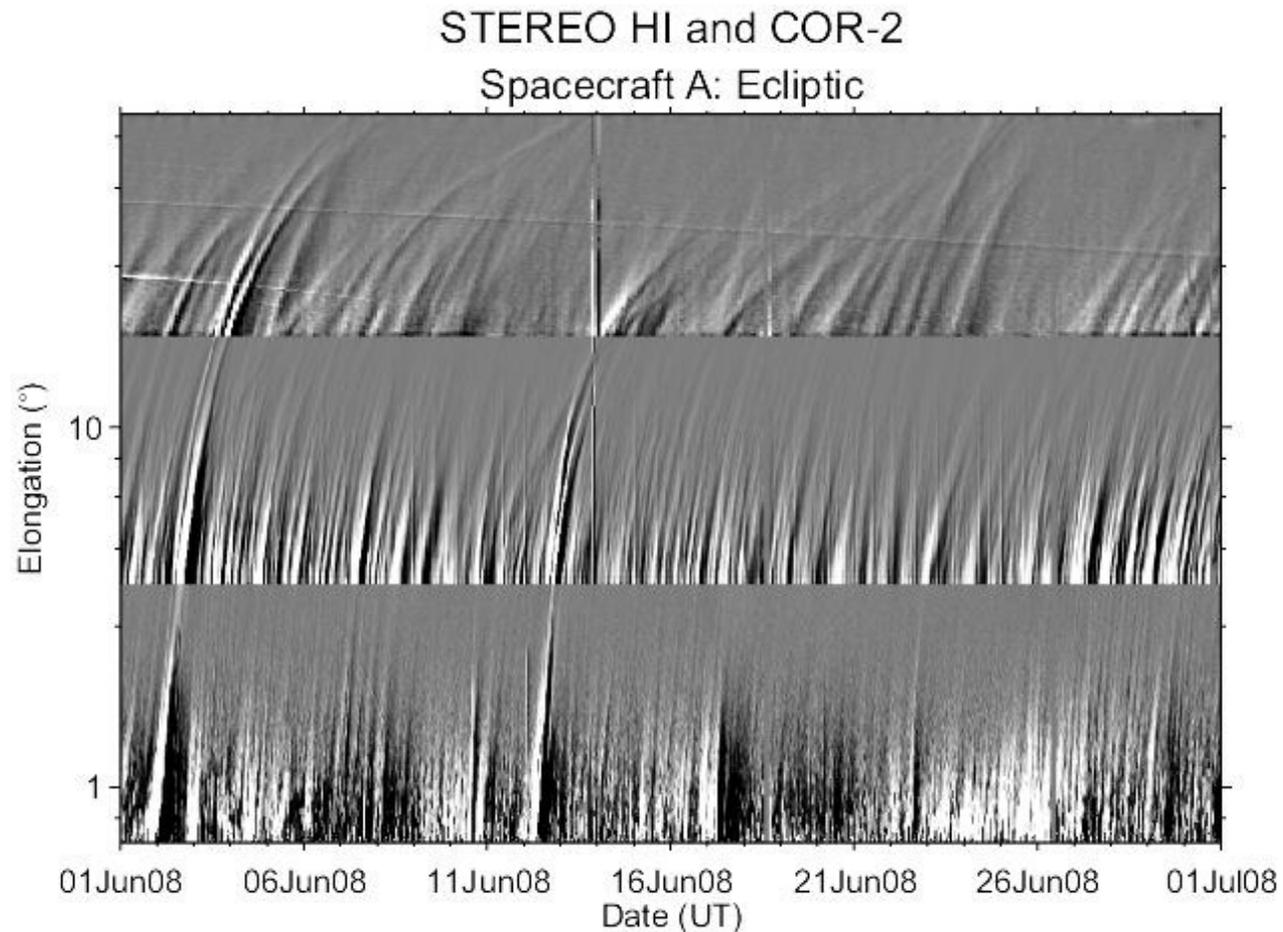
- Products: Images and movies, J-plots, c-maps
  - see <http://www.sstd.rl.ac.uk/stereo/>
- Exploitation – 67 publications known to the PI team
  - Includes 19 distinct institutes
  - Encompasses CME onsets, CME propagation and impacts at Earth and on other solar system bodies, cometary impacts, asteroids, stellar variability, CIRs, streamer ‘blobs’, dust...

## STEREO – Heliospheric Imagers – ‘Products’

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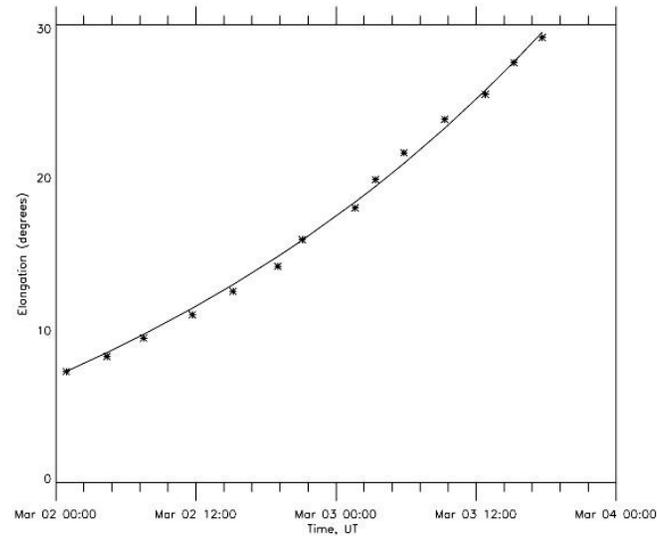
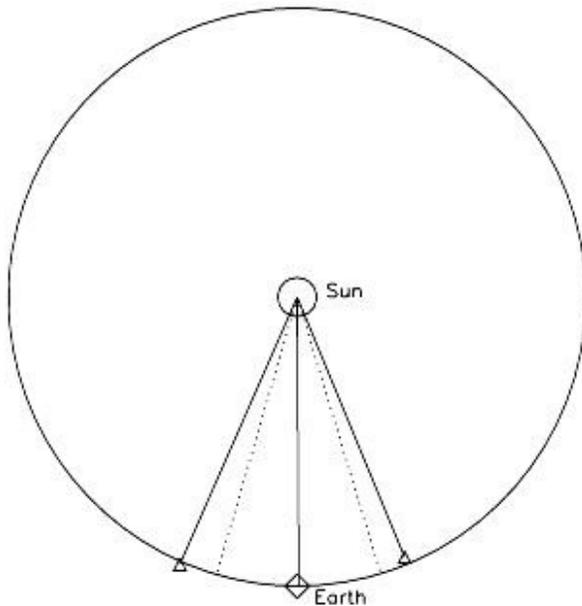
- J-plots – Fitting elongation-time profiles to determine both speed and direction with respect to the Sun-Earth line (see Davies et al., 2009)



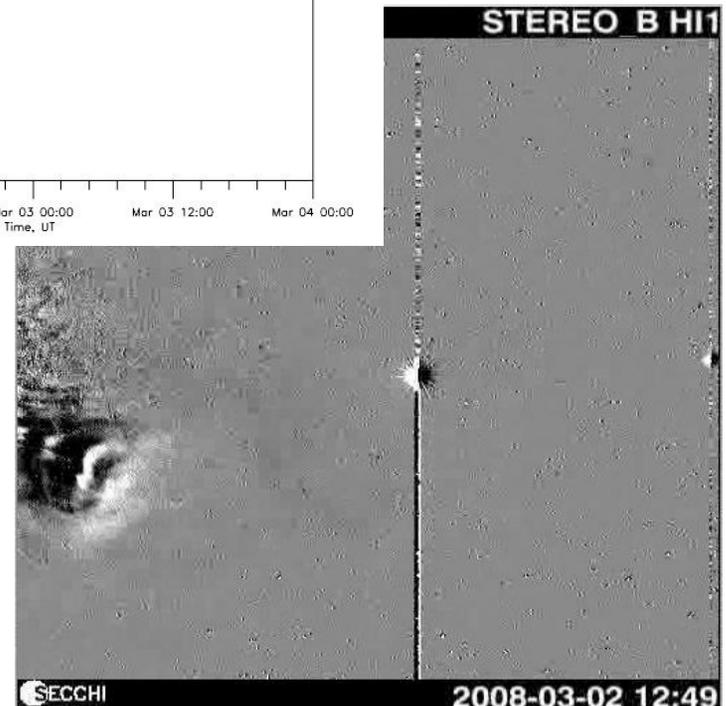
# STEREO – Heliospheric Imagers

- 109 HI ICMEs catalogued for 2007 and 2008 (see HI web site) – J-plot technique used to study the passage of CMEs in 3D (Harrison et al., in prep)

Event 157 launched: 2008-02-29T21:53:58.519  
Speed: 376 km/s Angle from Earth: 0 degrees  
Predicted arrival at 1 AU: 2008-03-05T11:26:16.221  
Observed with HI-B



Example product-set for 29 Feb 2008 ICME from event list – J-plot analysis appears to show Earth-impact - 12 similar impacts identified for 2008

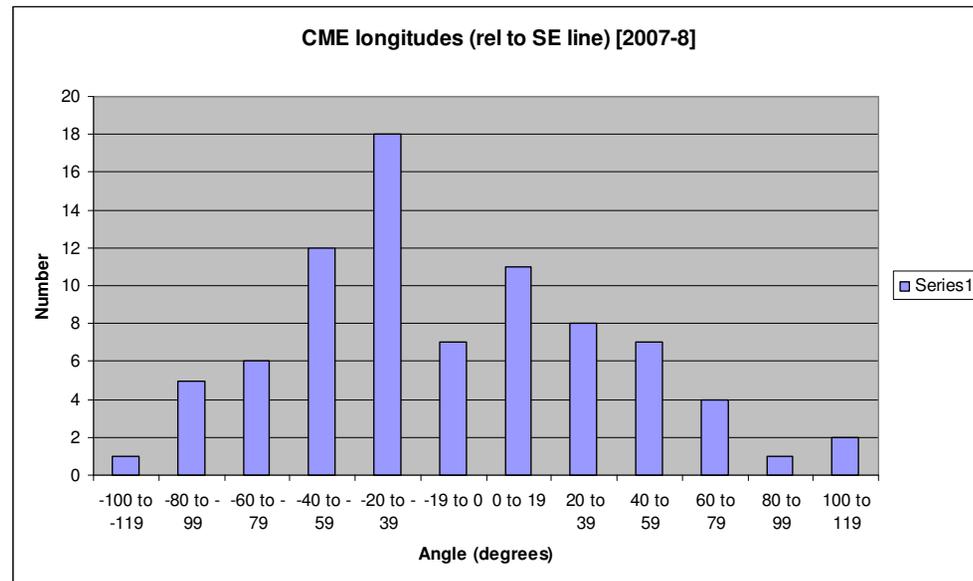
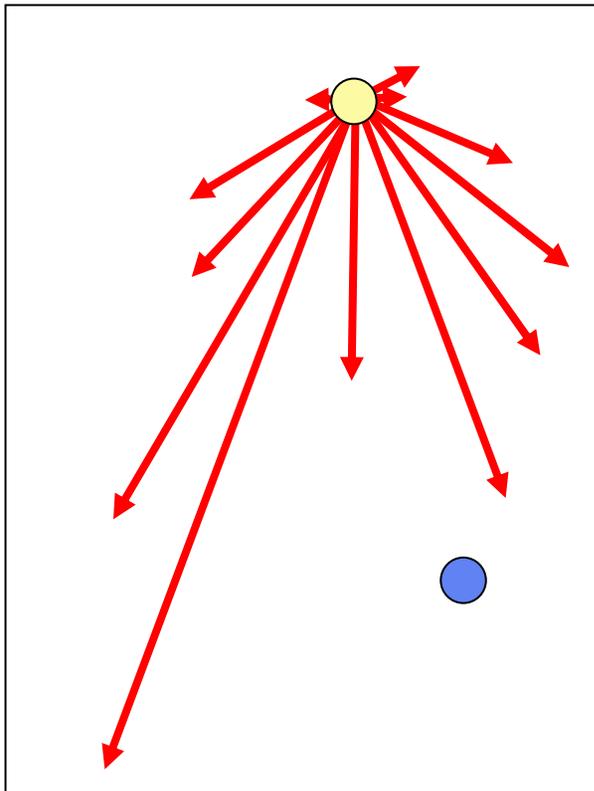


# STEREO – Heliospheric Imagers

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- 3D distribution of the 109 HI ICMEs from 2007 and 2008

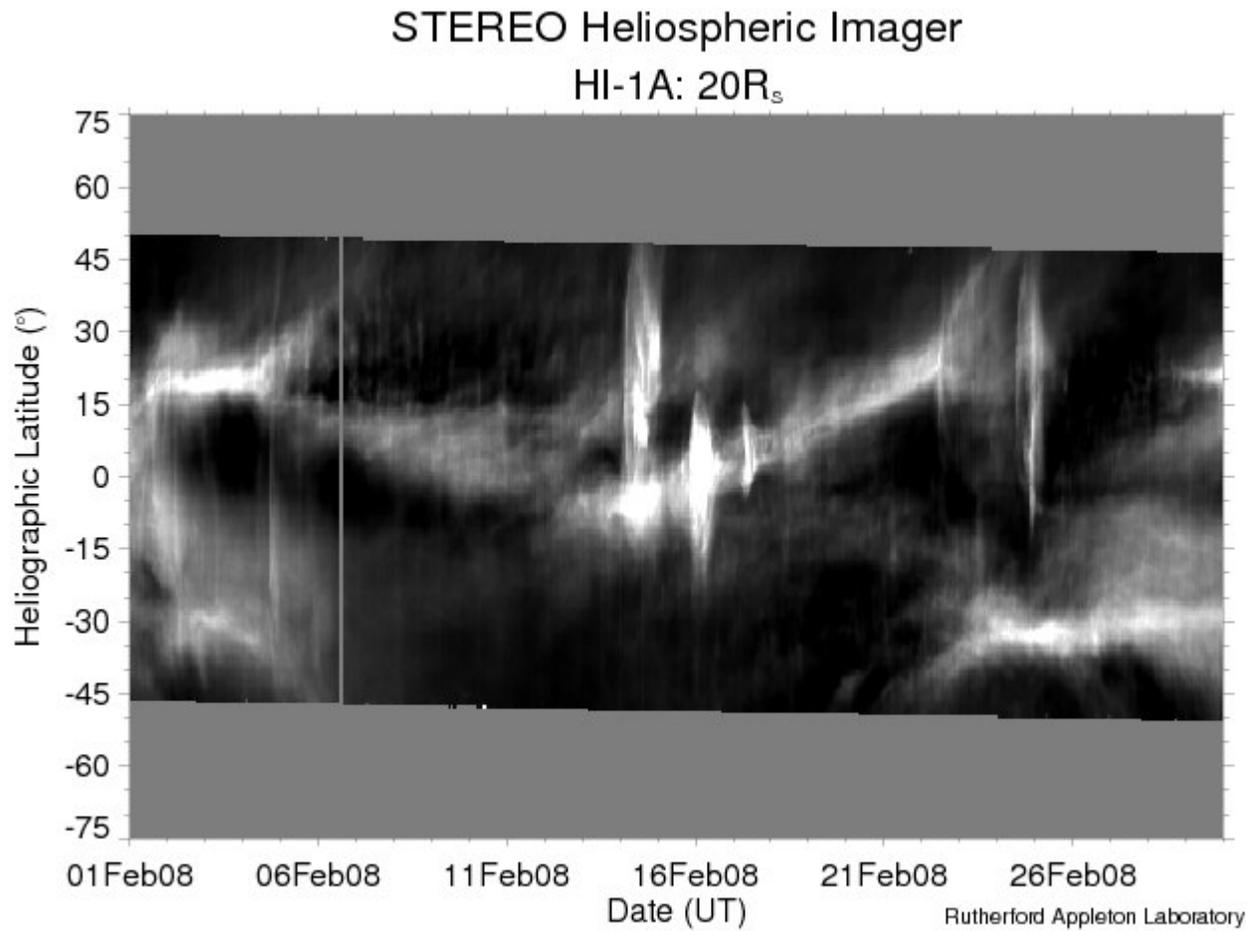


## STEREO – Heliospheric Imagers – ‘Products’

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- c-map – a Carrington style map showing the streamer belts and CME activity

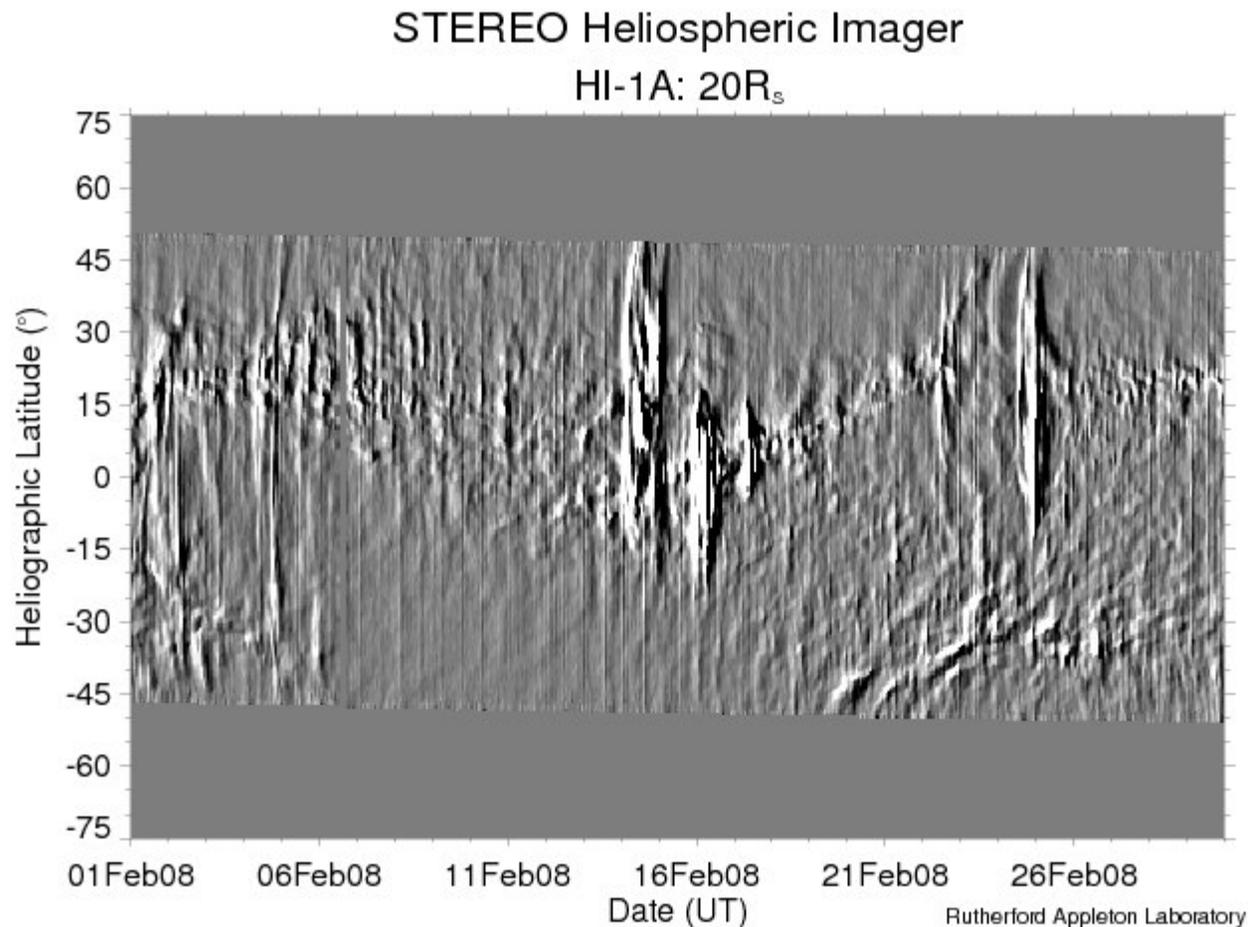


## STEREO – Heliospheric Imagers – ‘Products’

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- c-map – a Carrington style map showing the streamer belts and CME activity – a differenced version reveals fine structure in the steamer belts

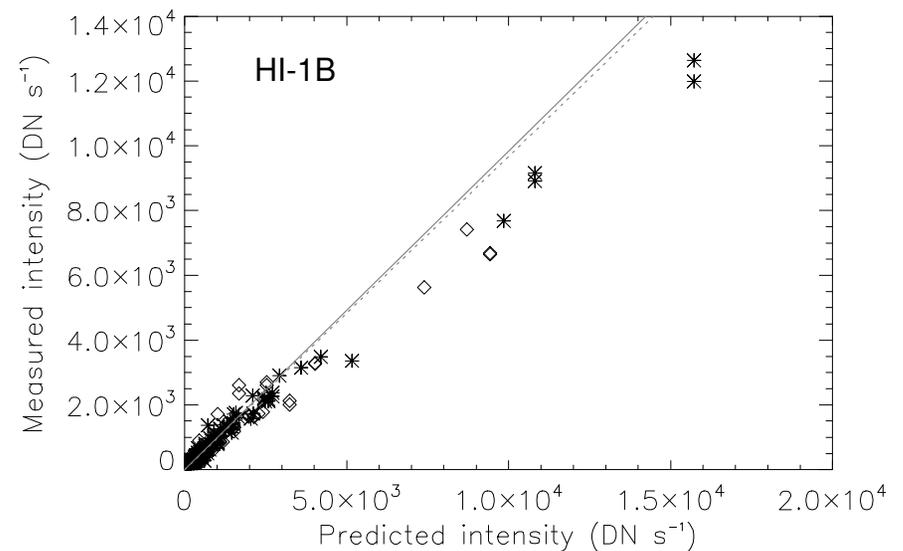
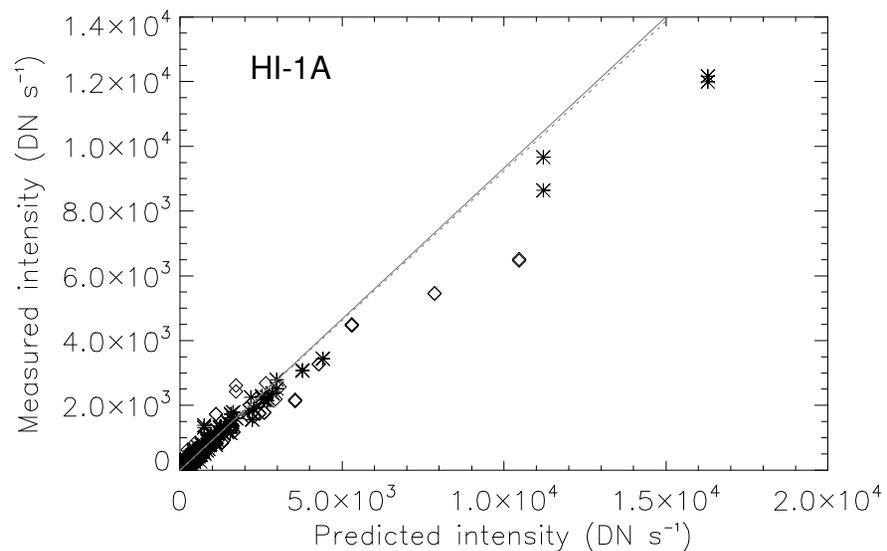


# STEREO – Heliospheric Imagers – Stellar Photometry Calibrations

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- Measured response to star determined by aperture photometry
- Compared with predicted response calculated by folding stellar spectrum through instrument response function
  - Many 100's of stars of various spectral types and known spectra used (903 and 541 for HI-1A and HI-1B, respectively)



*Note:* The outliers with large intensities lie below the fitted lines due to saturation effects. Including/excluding these has negligible effect on the fits.

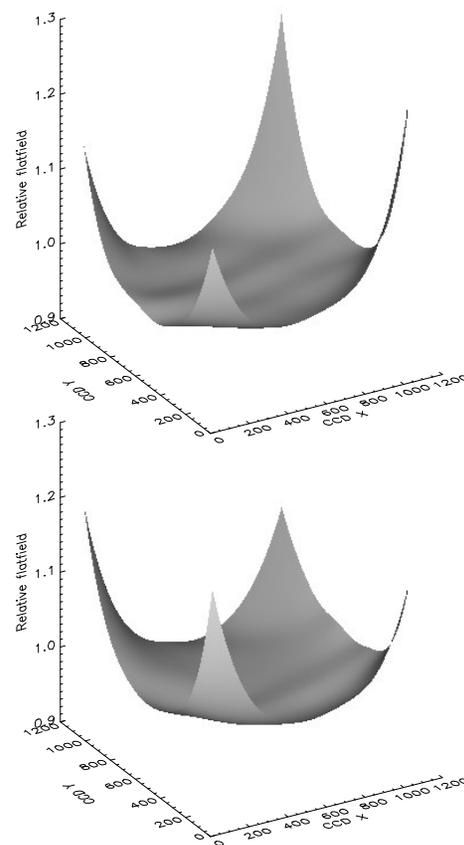
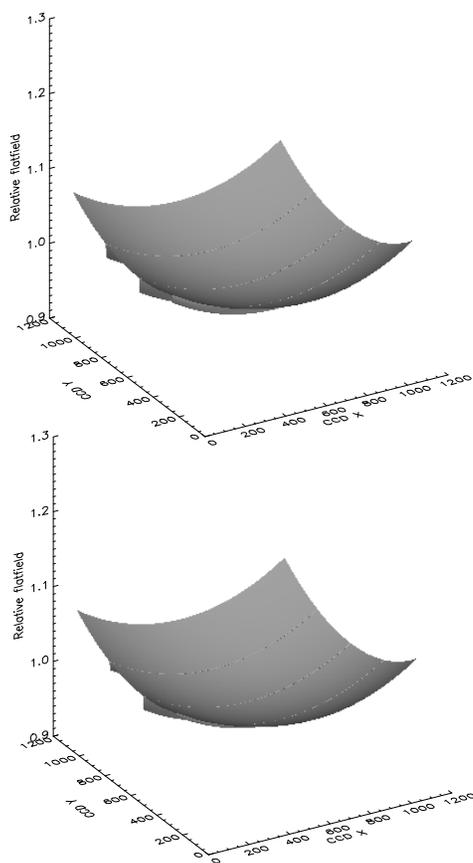
# STEREO – Heliospheric Imagers – Large-Scale Flat Field Responses

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- Slope of line calibrates absolute errors in the instrument response function (i.e. systematics such as absolute value of CCD QE, filter responses, CEB gain ...)
  - 0.93 for HI-1A; 0.98 for HI-1B
- Drift of stars across FOV enables flat-field calibration (for aperture photometry)

- Surface plots of pre-launch & optimised large-scale flatfield for HI-1A (top left & right) and HI-1B (bottom left & right)



## STEREO – Heliospheric Imagers – Calibration Factors for Diffuse Flux

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- Need conversion factors from DN s<sup>-1</sup> pixel<sup>-1</sup> to MSB (B<sub>O</sub>), S10 units and SI units
  - 1 S10 unit corresponds to flux of 10<sup>m</sup> star (of solar spectral type) spread over 1 square deg of sky
  - SI units measured in W m<sup>-2</sup> s<sup>-1</sup> over 300-1080 nm (overall waveband of HI-1)
- Solar spectrum data of Neckel & Labs (1984) folded through calibrated HI-1 instrument response
  - Gives **total** response I<sub>O</sub> in DN s<sup>-1</sup> if instrument were to view solar disk.
- Procedure to obtain conversion factor C<sub>MSB</sub> (from DN s<sup>-1</sup> pixel<sup>-1</sup> to B<sub>O</sub>) is then
$$C_{\text{MSB}} = n_{\text{pix}} / I_{\text{O}}$$
 where n<sub>pix</sub> is number of pixels imaging solar disc, and
$$n_{\text{pix}} = \pi (D_{\text{O}} / 2 * d_{\text{pix}})$$
 where d<sub>pix</sub> is angular dimension of pixel.
- Similar procedures for other two conversion factors.

## STEREO – Heliospheric Imagers – Calibration Factors for Diffuse Flux

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- Conversion factors from DN s<sup>-1</sup> pixel<sup>-1</sup> to diffuse flux units –

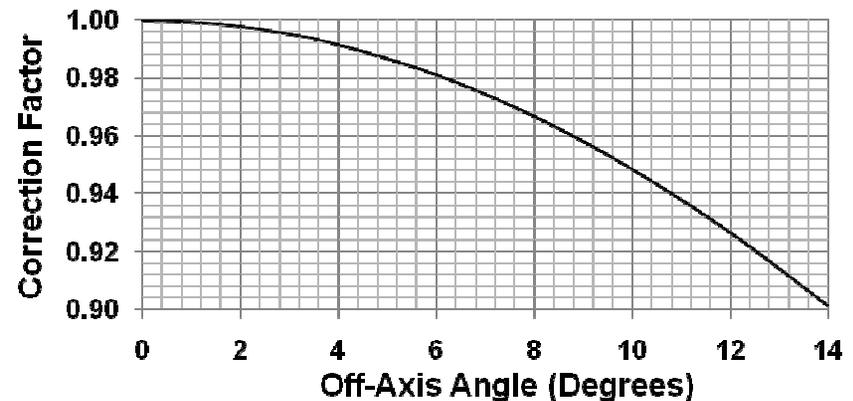
	$C_{MSB}$	$C_{S10}$	$C_{SI}$
HI-1A	$8.99 \times 10^{-14}$	199.8	$1.40 \times 10^{-6}$
HI-1B	$9.04 \times 10^{-14}$	200.9	$1.41 \times 10^{-6}$

- Note these are values ***on-axis***; the pixel size varies significantly off-axis for HI
- Can derive the off-axis correction to these factors using the HI image projection -

$$R = F_p (\mu + 1) \sin \alpha / (\mu + \cos \alpha) \text{ where } F_p \text{ is the paraxial focal length}$$

$\mu$  is a distortion param (Brown *et al.*, 2009)

- This is effectively an additional flat-field correction to be applied for diffuse objects in addition to the FF correction derived from stellar photometry.



# SOLAR STORMWATCH

- HOME
- WHY SCIENTISTS NEED YOU
- MISSION BRIEFING
- SPOT & TRACK STORMS
- TALK ABOUT IT

## Solar scientists need you!

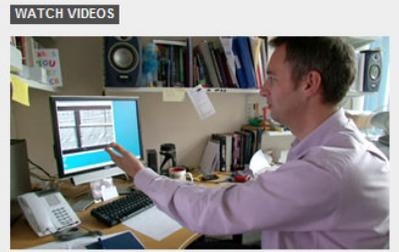
Help them spot explosions on the Sun and track them across space to Earth. Your work will give astronauts an early warning if dangerous solar radiation is headed their way. And you could make a new scientific discovery.

[GET STARTED](#)

Photo by NASA

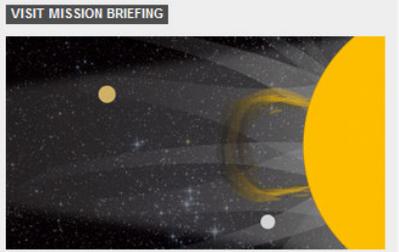
### WHY SCIENTISTS NEED YOU

Watch our solar scientists explain why your contributions are vital, and find out what they're doing with your results behind the scenes.



### MISSION BRIEFING

Explore our interactive mission briefing to get up to speed with solar science, zoom in on the STEREO spacecraft and meet our science team.



### Featured member

**Hannah Hutchins**

Member since: August 2008

I love being able to contribute to science, it's fun and there are so many amazing things to learn about. The forum is a very nice and friendly place to be a part of and you get to meet the people in person at the Galaxy Zoo meet-ups.

**Achievements**



### TALK ABOUT IT

Share your discoveries on the forum and Flickr, check out the space weather forecast on Twitter, and read our blog for all the latest news and challenges.

[Solar Stormwatch blog](#)

**My solar stormwatch**

Now that many of you have been tracking solar storms for some time, we are starting to build up enough data to identify some storms from the large numbers of people i...

[READ MORE](#)

**We get a radical perspective when you work as a collective.**

Thanks to everyone for their efforts so far. Now that we have had a significant number of storms tracked, we can start looking at the data in order to see how we

### Space weather forecast

Over 500 Incoming! classifications so far... and new solar storm data every three hours. [20 days ago](#)

[SOLAR STORMWATCH FORUM](#)

### Latest Flickr photos

by Per I.      by Smárinn      by Atlimann

[SEE MORE PHOTOS](#)

### For teachers

If you're a teacher, we've got all you need to include Solar Stormwatch in your lessons at Key stages 3 and 4.

[TEACHERS' RESOURCES](#)

10,011 members and counting

# SOLAR STORMWATCH

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## SPOT

### QUESTION

When did the front of the solar storm get to the dotted halfway line in the STEREO Ahead camera?

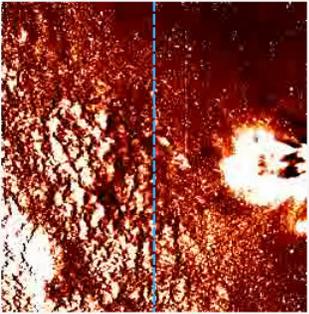
### INSTRUCTIONS

Play the video until the front of the solar storm is roughly at the dotted halfway line. Then use the nudge **FORWARD** and **BACK** buttons to find exactly when the storm reached it. Press the **HALFWAY NOW** button to record your answer.

STEREO BEHIND



STEREO AHEAD



PLAY

PAUSE

BACK

FORWARD

★ ADD CLIP TO FAVOURITES

Time - 12:50

### YOUR ANSWER

#### STEREO AHEAD

HALFWAY NOW

### ? Hints & tips

- If you think there is more than one solar storm in this clip, just pick your favourite. You'll get a chance to record another one at the end.
- Remember, solar storms begin from the outside edge of the cameras, and move towards the middle.
- Watch a *How to...* screencast.

HOW TO...  
**SPOT A SOLAR STORM (1)**  
★ ADD CLIP TO FAVOURITES  
3:58

HOW TO...  
**SPOT A SOLAR STORM (2)**  
★ ADD CLIP TO FAVOURITES  
4:01

### i Extra info

#### What's the point of this measurement?

First we're asking you to mark when your solar storm gets halfway across the camera. Next you'll get to spot when it first appears. From these measurements we can make a rough estimate of its speed and, if you're making measurements in both cameras, its direction.

#### QUICK LINKS

- Teachers resources
- Why scientists need you
- Sun, Earth & space
- The STEREO spacecraft
- Solar Stormwatch forum

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# SOLAR STORMWATCH

HOME	WHY SCIENTISTS NEED YOU
	MISSION BRIEFING
	<b>SPOT &amp; TRACK STORMS</b>
	TALK ABOUT IT

## WHAT'S THAT?

### QUESTION

Can you spot comets, particle strikes or anything else interesting?

### INSTRUCTIONS

Watch the video. If you spot something, pause it, then use the nudge **FORWARD** and **BACK** buttons to find the frame when it's most visible. Then press the relevant **RECORD** button in the answer section.

STEREO BEHIND

STEREO AHEAD

PLAY

PAUSE

BACK

FORWARD

ADD CLIP TO FAVOURITES

Time - 10:20

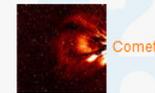
### YOUR ANSWER

<b>COMET</b>	<b>PARTICLE STRIKE</b>	<b>OPTICAL EFFECT</b>	<b>SOMETHING ELSE</b>	
RECORD	RECORD	RECORD	RECORD	<b>NOTHING TO SEE</b>
<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	

TIMESTAMPED: \_\_\_\_\_

### Hints & tips

- Want to double-check what each feature should look like? OK.



Comet



Particle strike



Optical effects

See more examples on Flickr. (opens in a new window)

- It's ok if something appears more than once, just record both times it appears.
- You can record more than one type of feature per video clip.
- Watch a *How to...* screencast.

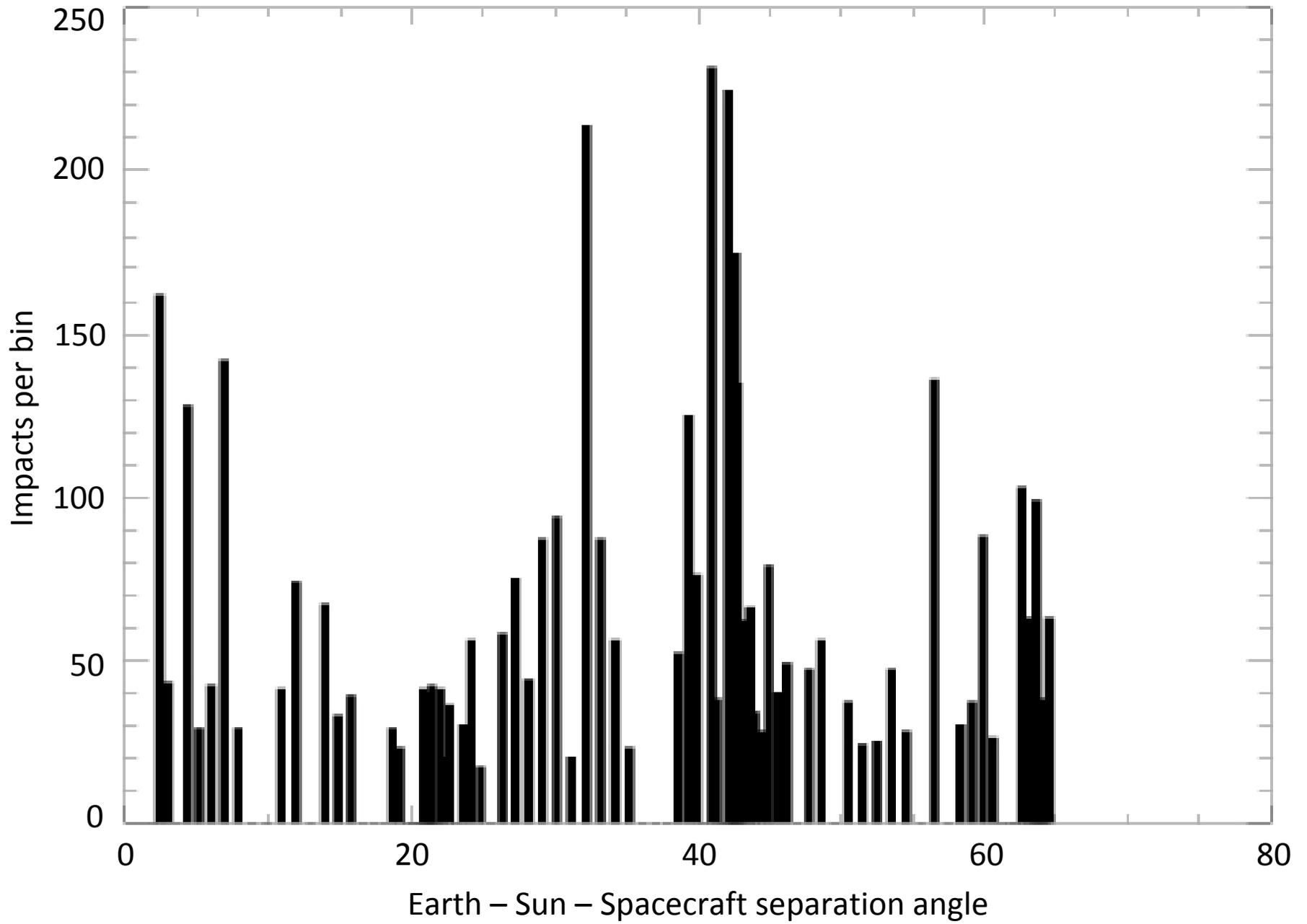
HOW TO...  
PLAY  
WHAT'S  
THAT? 3:54

ADD CLIP TO FAVOURITES

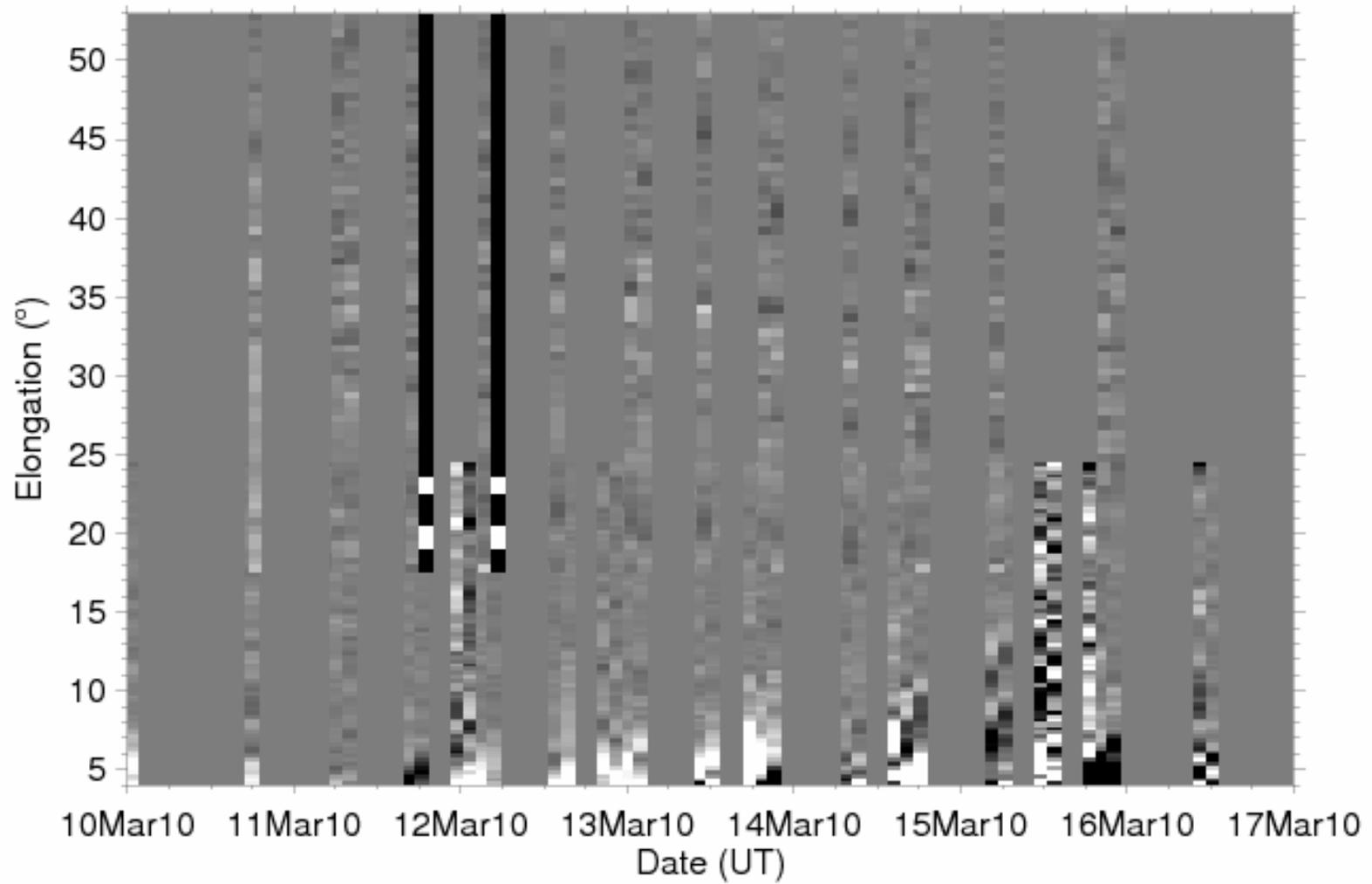
### Extra info

Why do scientists want me to spot these features?

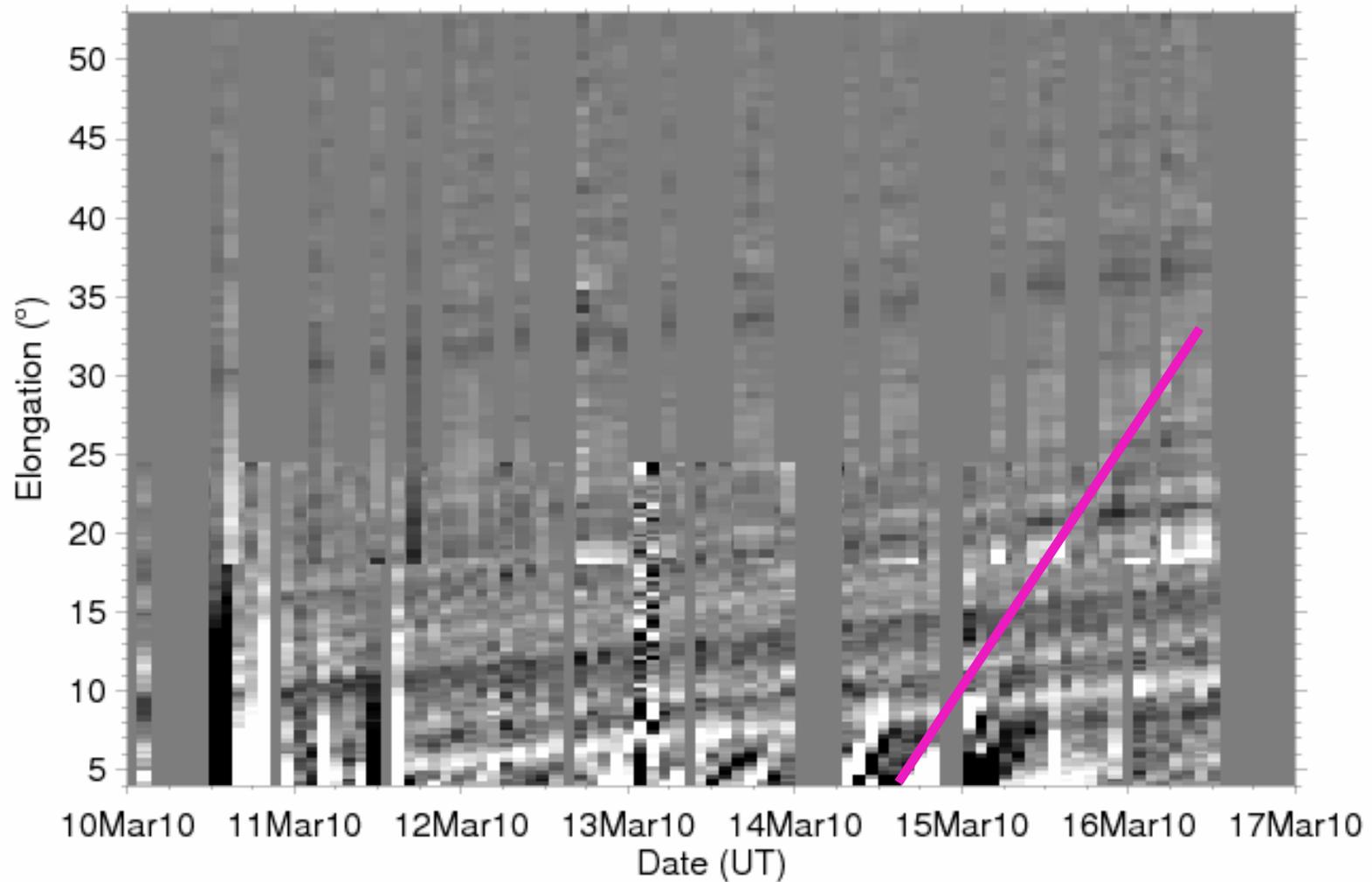
STEREO's heliospheric imagers capture a wide angle view of space, which means they snap all sorts of interesting and unexpected things besides solar storms. But so far scientists don't know what's common and what's not. Your work will help provide the answers.



# STEREO BEACON MODE STEREO/HI-A



# STEREO BEACON MODE STEREO/HI-B



CME launched on 14<sup>th</sup> March predicted to arrive at 1 AU at 12 UT on 18<sup>th</sup> March  $\pm$  5 hours travelling at a longitude of  $-21 \pm 17$  degrees